

**Title:**

**Safe Decontamination and Demolition of Explosives-processing Facilities.**

**Author:**

Robert (Bob) Ford, President, Safety Management Services, Inc.

**Contact Information:**

Safety Management Services, Inc.

1847 West 9000 South, Suite 205

West Jordan, Utah 84088

USA

**Office:** (801) 567-0456 **Cell:** (801) 580-4591 **Fax:** (801) 567-0457

**E-mail:** rford@sms-ink.com **Website:** www.sms-ink.com

**Abstract:**

This paper provides insight to applying explosive safety and risk management principles to the unique issues associated with decontamination, disassembly, and demolition (D3) of equipment and facilities that have previously been used for manufacturing or Demilitarization of explosive materials and/or articles. SMS and the Arcadis Team have successfully completed the D3 operations for all high hazard facilities at a decommissioned rocket motor manufacturing facility. The completion of these operations enables additional insights and explanations regarding the risk management protocol and procedures that contributed to the safe removal of equipment and facilities contaminated with various explosive materials. Improper D3 of such locations could have resulted in serious injury or death of personnel. Successful implementation of explosives safety, risk management, and engineering principles has resulted in project completion with no lost time injuries (over 900,000 man hours).

This paper addresses specific examples of the significant challenges encountered and the risk management systems implemented to ensure safe D3 operations. It also illustrates how the fundamental principles of explosives safety have been woven into all aspects of hazard identification, D3 protocol/procedures, personnel training, and site management.

**Biography:**

Bob is a Mechanical Engineer with over 25 years experience in the explosives industry. He founded and is currently the president of **Safety Management Services, Inc. (SMS)**. SMS is comprised of engineers and scientists with expertise/experience applying risk management methodology to a wide variety of energetic and hazardous material processes. SMS is also approved by the US Department of Transportation to conduct and witness testing to determine appropriate shipping classifications for explosive substances and articles.

**Paper:**

It is a significant challenge to perform decontamination, disassembly, and demolition (D3) operations associated with closure of explosives-processing buildings or plants without personnel injury. However this challenge can be met by systematic application of: 1) Explosives Safety and Risk Management Principles, 2) Technologies and Engineering Discipline, 3) Trained and Experienced Personnel, and 4) a focused Project Management Team. The governing philosophy

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from concept to completion of D3 operations must be to “Limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of explosives consistent with safe and efficient operations” (ref. DoD 4145.26-M, Chapter 3).

A sound understanding of the fundamental principles of explosives safety is required. The team must understand the nature (i.e., sensitivity and reactivity) of the energetic materials present. Composition, contamination, configuration, and confinement can all have a significant affect on how the material will respond to D3 operations. Thorough and accurate hazards analysis must accompany the selection and application of technology/techniques. The analysis must be updated or revised as unexpected conditions arise. Facility siting protocol must be followed to ensure protection of site personnel and the public. Applicable governing explosives safety standards as well as site-specific standards/guidelines must serve as a benchmark for safe operations. Such standards are based on the lessons learned from past incidents, hazards analysis, and best industry practices. Rigorous process controls such as Pre-startup Safety Reviews, Mechanical Integrity of critical D3 equipment, and Management of Change ensure that D3 operations proceed with all potential risks understood and acceptable levels achieved. It is also very important that the D3 operations team integrate explosives safety systems and protocols into all elements of a good risk management plan. Figure 1 illustrates the elements and their proper relationship pertaining to a successful risk management plan. Ownership and accountability for explosives safety and risk management must cross all organizational boundaries and be felt by all personnel on the D3 team.

Figure 1

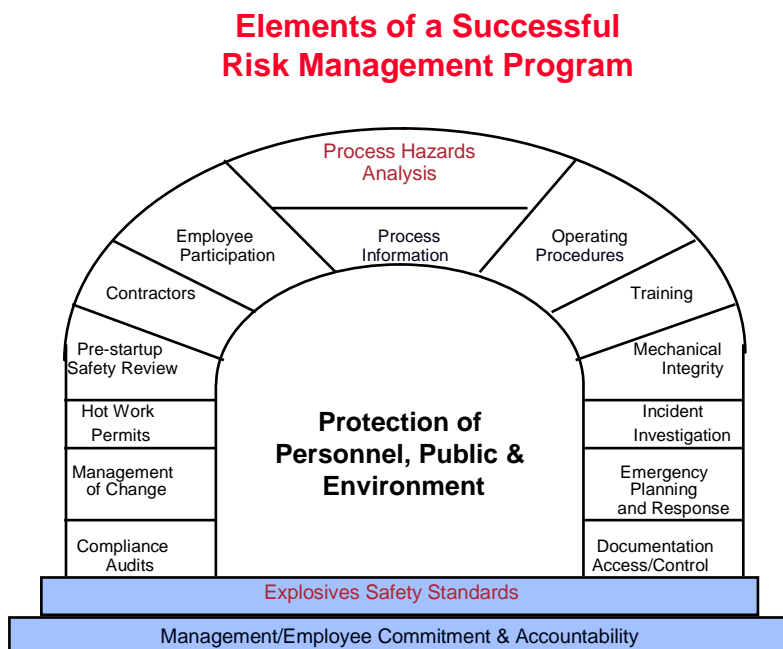
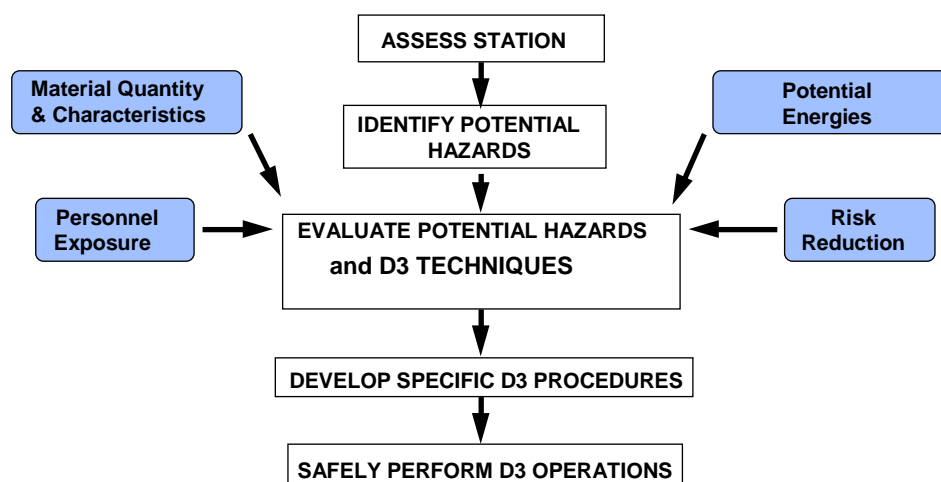


Figure 2 outlines the risk management approach to D3 operations for a given station. The station may be defined as a stand alone building or a building with all ancillary support facilities. The approach begins by assessing the station to gain a good understanding of its past utilization and thus

potential existing hazards. Information on the station is gathered from existing documentation, interviews with personnel who have worked at the station, and by observing the station with all appropriate precautions. This allows the development of a comprehensive Sampling and Analysis Plan. The plan defines the type of sampling required and the procedures required to obtain the sample safely. Most stations will require some intrusive sampling and investigation to determine the level of contamination behind wall or under flooring. Such techniques obviously require hazards analysis and procedures that minimize the associated hazards and exposure to personnel. Two key objectives of the station assessment are to establish appropriate decontamination performance criteria and to clearly communicate the explosives contamination issues to the team.

Figure 2

## RISK MANAGEMENT APPROACH TO D3



Station potential hazards are thus identified by performing field samples and inspections. Field sampling kits such as 1) HAZCAT® Rocket Fuel Test Kit which tests primarily for ammonium perchlorate and 2) Expray® Test Kit which detects polynitroaromatics, nitramines, nitrate esters, and inorganic nitrates have proven very effective. Laboratory wipe samples are also used to confirm the presence of AP, HMX, RDX, NG, or NC. Remote core sampling allows sampling and inspection of walls, floors, etc. and provides access to utilize a Borescope to inspect suspect locations. Of course a rigorous hazards analysis is required of the Borescope configuration prior to such applications. Inspections of hidden spaces, feed systems, ventilation systems, process piping, etc. require systematic procedures and protocols to ensure personnel safety.

Portable X-Ray equipment has proven a valuable technique to determine the presence of bulk energetic materials in process piping. This technique coupled with Borescoping is very useful in developing strategies for process pipe cutting/removal. However it should be noted that access and detection limitations exist that must be addressed in the development of subsequent D3 procedures.

The Station Assessment provides the basis for the evaluation of the potential hazards of a given station and the selection of D3 techniques that should be utilized. Potential hazardous locations include ingredient grinding equipment and components, mixing and casting equipment, process piping such as vacuum piping and feed systems, hoppers, tooling, heating and air conditioning systems, laboratories, etc. Each of these pose unique potential hazards that must be evaluated to understand the risk associated with the selected D3 techniques.

Examples of D3 techniques include manual decontamination and disassembly, remote pipe cutting, thermal decontamination, washout, hazard reduction burning, and decontamination by demolition. Each of these techniques applies energy to the potentially contaminated station components. Therefore a systematic hazards analysis must be performed on each technique to understand the potential hazards associated with normal and abnormal operations. The hazards analyses for each technique can be updated or modified to address the unique energetic material compositions, equipment configurations, etc. that exist for a given station. It is important that the hazards analysis identifies all potential hazards, establishes a hazard ranking, and focuses on risk mitigating measures.

Manual decontamination and disassembly of equipment contaminated with energetic material can be performed safely provided that the material can be desensitized through wetting or other means. Approved vacuum systems and pressure washing techniques have been used successfully. There is also merit to utilizing a dedicated decontamination station that provides a consistent and controlled environment for attended and semi-attended cleaning of contaminated equipment and components. Such a decontamination station must provide for personnel egress, have detailed operating procedures, and an approved deluge/sprinkler fire protection system. The station could utilize a pressure washer, dewatering box, micron filtration system, above ground contaminated water accumulation tank, and a bridge crane for handling larger items.

Explosives-contaminated process piping has always posed a significant hazard to the explosives industry. There have been numerous incidents that have resulted in serious injury or death of personnel performing maintenance, disassembly, cleaning, and/or other such operations on contaminated piping. Propellant, Explosives, or Pyrotechnic (PEP) contaminated piping can be found in mixing and casting facilities, laboratories, hydrolysis units, ovens etc. PEP contamination can also be found in unexpected locations such as unmarked lines, dry deluge systems, compressed air lines etc. All piping should be considered to be contaminated until inspection and sampling confirm that no PEP materials are present.

Remote pipe cutting has proven to be a valuable technique for piping access and disassembly. Hazards analysis of the selected method for remote pipe cutting is essential. The hazards associated with equipment setup, cutting and pipe handling must be thoroughly evaluated. The hazards analysis must address thermal heating, impact, friction, and electrostatic energies, and the sensitivity of the PEP materials. As previously mentioned, X-ray and Borescoping can prove valuable in determining cut locations that have minimal risk. Standard operating procedures and scaffolding strategies are also important. Remote pipe cutting necessitates a portable control room that is designed and located for the Maximum Credible Event (MCE). Such a control room should have adequate video monitoring capability and emergency shut down capability.

Thermal Decontamination is a viable solution for safe decontamination of equipment and facilities that have hazardous quantities of PEP materials in hidden spaces or locations that cannot be safely accessed. Portable Thermal Verification Ovens are available for equipment or components that can be safely handled. High efficiency, reusable, thermal enclosures constructed around the item or facility are also an option. Such enclosures and the associated heating system must be capable of sustaining sufficient temperatures for the appropriate time to ensure all PEP materials are reacted and rendered safe. These systems should be remotely operated. Properly placed thermocouples and recording instrumentation document the decontamination process. Exhaust Emission Reduction systems are probably required to comply with environmental regulations.

Decontamination by Demolition is a viable approach for stations that have PEP contamination that is fully understood and that are at levels that pose little to no risk to personnel. Complete decontamination may not be required if contamination levels are such that the items/components can be sent to facilities approved for final disposition. Shielded excavators minimize personnel exposure while demolishing facilities. Demolition can be staggered to allow for additional inspection, verification, and segregation of materials.

In addition to potential hazards associated with explosives-contaminated facilities, there are other potential hazards and concerns that must not be overlooked. Potential hazards such as asbestos-containing materials, PCBs, mercury, oils, CFCs, lead based paint, etc. Concerns could include asset management and recovery, waste management, environmental, and ecological considerations, etc.

## **Summary**

Decontamination, disassembly and demolition (D3) of equipment and facilities previously used for explosives processing pose unique and challenging risks. These risks can be minimized by proper assessment of the station, systematic hazards analysis, and application of appropriate D3 techniques. Successful D3 operations require the integration of explosives safety and risk management principles into all aspects of a D3 project.

SMS and the Arcadis Team have demonstrated the proper application of these principles by completing D3 operations for all high hazard facilities at a decommissioned rocket motor manufacturing facility (over 900,000 hours) with no lost time injuries.

# Safe Decontamination and Demolition of Explosives-processing Facilities

***Presenter:  
Bob Ford – SMS***

***July 2010***



**Pratt & Whitney**

A United Technologies Company

 **ARCADIS**  
Infrastructure, environment, buildings

**S***afety*  
**M***anagement*  
**S***ervices, Inc.*

 **VEOLIA**  
ENVIRONMENTAL  
SERVICES

# Pratt & Whitney Rocketdyne (PWR): San Jose Site

## Decommissioning, Decontamination and Demolition (D3) Project

Note: D3 Operations were contracted to ARCADIS by PWR San Jose and this presentation outlines the major challenges and lessons learned from safe completion of the project.



# Pratt & Whitney Rocketdyne (PWR): San Jose Site



# P&WR San Jose Site Decommissioning & Remediation

## Program Scope/Overview

- Facility decommissioning and remediation
- Manage and perform all aspects of future use evaluations and D&D programs
- 200 + buildings; 5,000 acres
- Facility decommissioning:
  - Assessment of energetics, regulated materials, and other hazards in facility buildings





# P&WR

## San Jose, California (continued)

- Facility decommissioning (continued):
  - Design of decontamination and demolition techniques (remote operations, hazard burns, etc.)
  - Turnkey decontamination and demolition
  - Comprehensive safety assessment and safety oversight program
  - Site-wide permitting
  - Ecological evaluations/restoration design
  - Alignment of D&D, remediation, permitting, and future development plans



# Team Members

- **ARCADIS** – Prime Contractor
- **SMS** – Explosives Safety
- **VES** – Specialty and high hazard decontamination
- **PIKA** – Thermal Treatment
- **Sevenson** – Demolition, rigging, and earthwork



# The PWR Challenge

- Decommissioning, Decontamination, and Demolition (D3) of Equipment and Facilities Contaminated with Energetic Materials without Personnel Injury.

# “Cardinal Rule” of Explosives Safety

“Limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of explosives consistent with ***safe and efficient operations***”

(ref. DoD 4145.26-M, Chapter 3)

# Elements of a Successful Risk Management Program

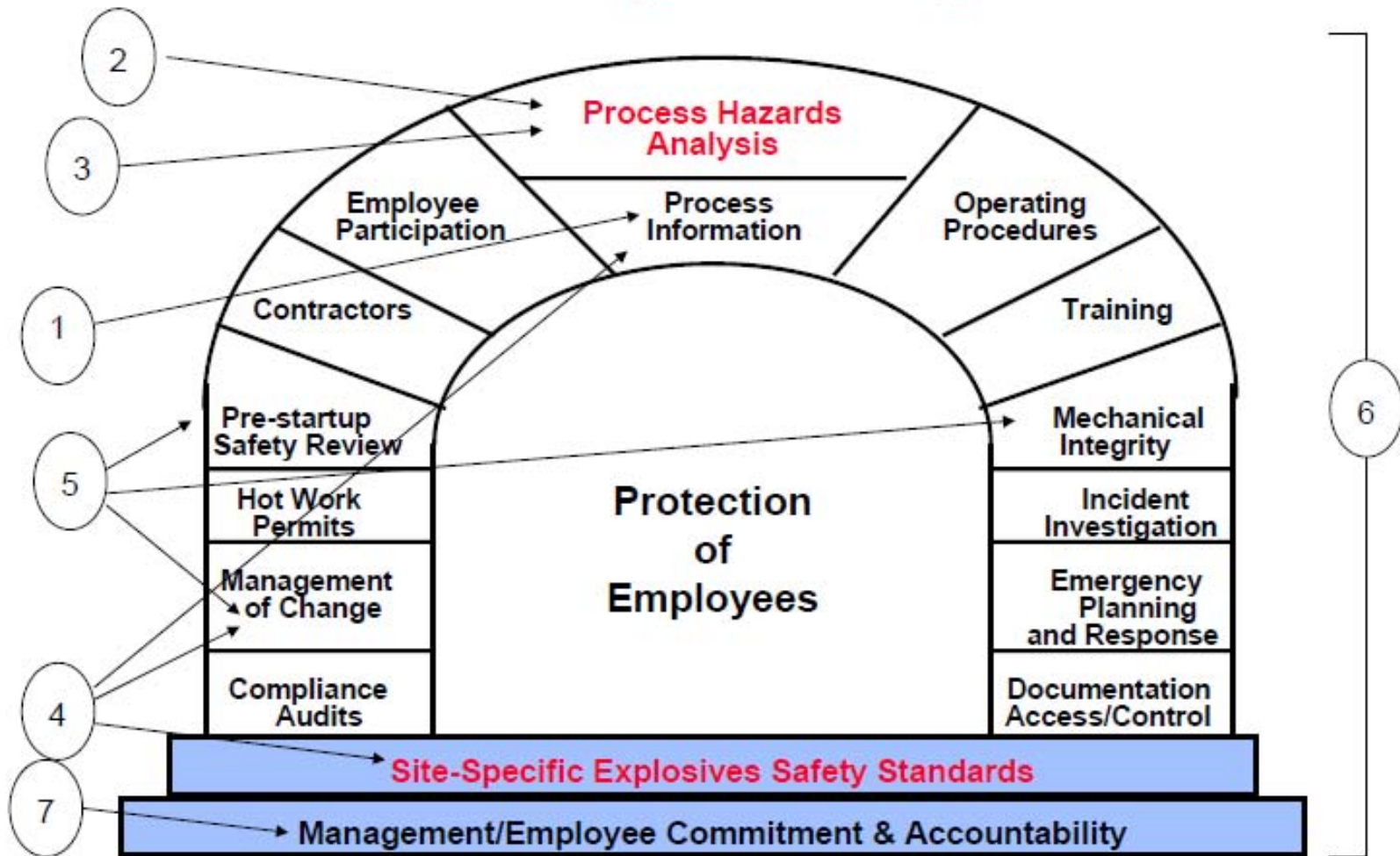


# Fundamental Principles of Explosives Safety

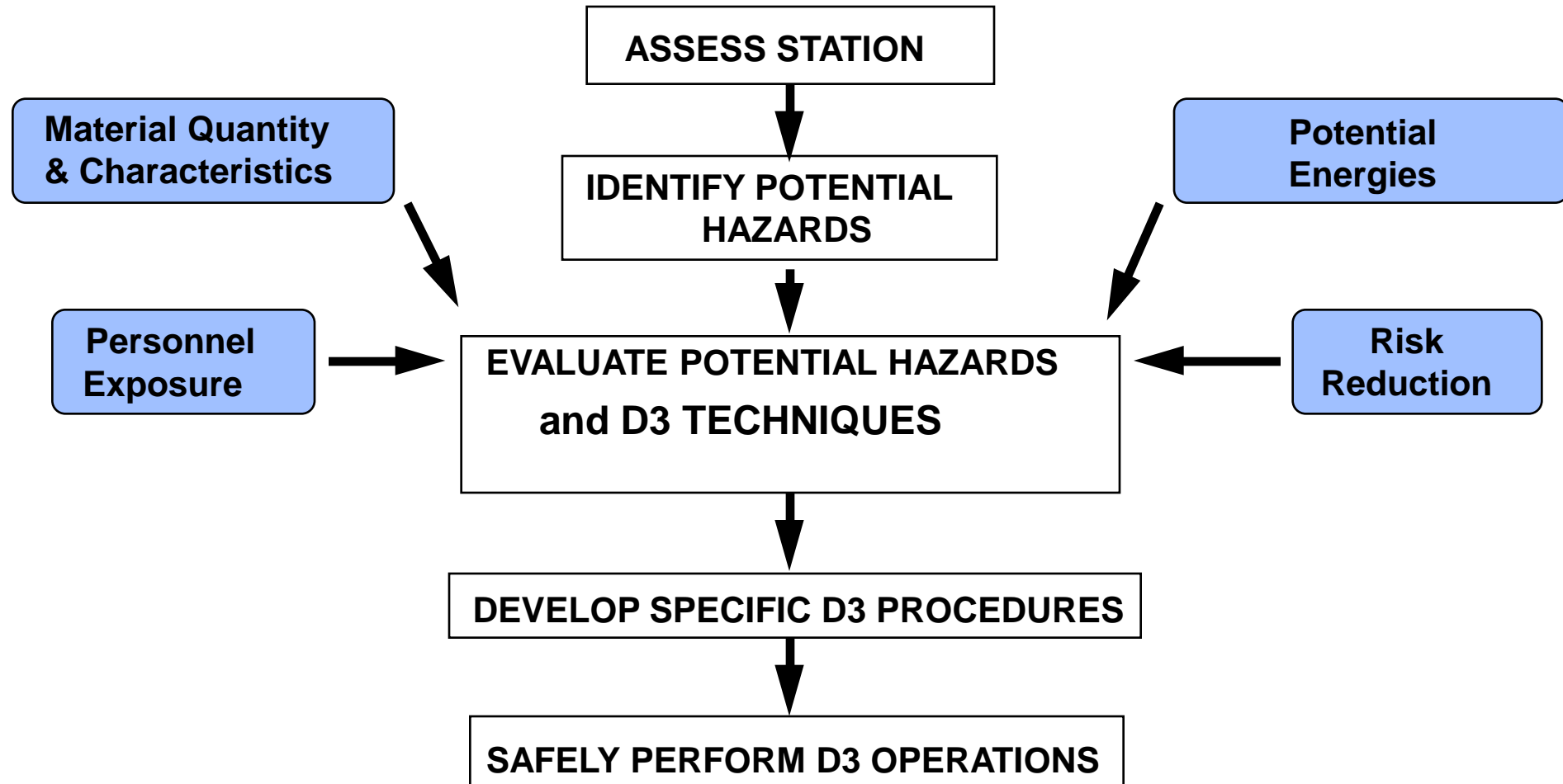
1. Understand the Nature of Explosives “In Process”, Storage, or Transportation
2. Thorough & Accurate Process Hazards Analysis (PHA)
3. Proper Facility Design and Siting
4. Site-Specific Guidelines based on lessons learned and PHAs
5. Rigorous Process Control
6. Explosives Safety Systems and Protocols
7. Explosives Safety Accountabilities at all Organizational Levels



# Risk Management Program & Explosives Safety Principles



# RISK MANAGEMENT APPROACH TO D3



# D3 Technologies and Techniques

- Remote Pipe Cutting
- Remote Coring
- High Pressure Water Jet Cutting
- Remote Container Opening
- In-situ Hot Gas Decontamination
- Mobile Decontamination Oven
- Fixed and Portable Decontamination Systems

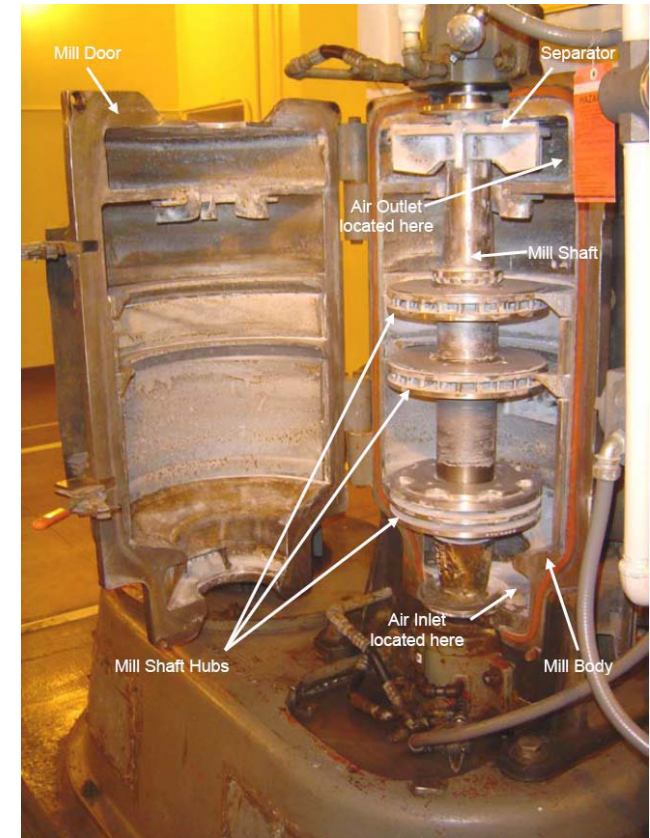
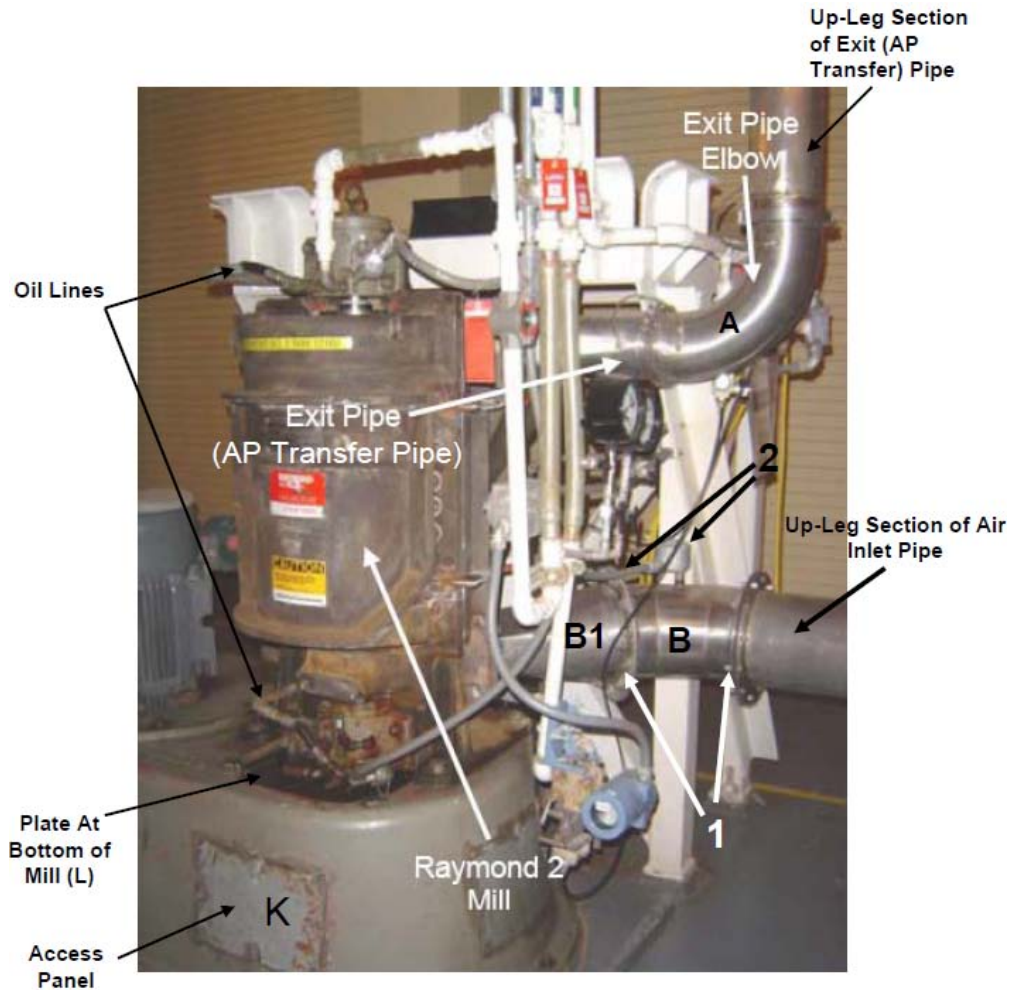
# Explosives Safety Challenges

# AP Grinding Building





# Inside AP Grinding mill

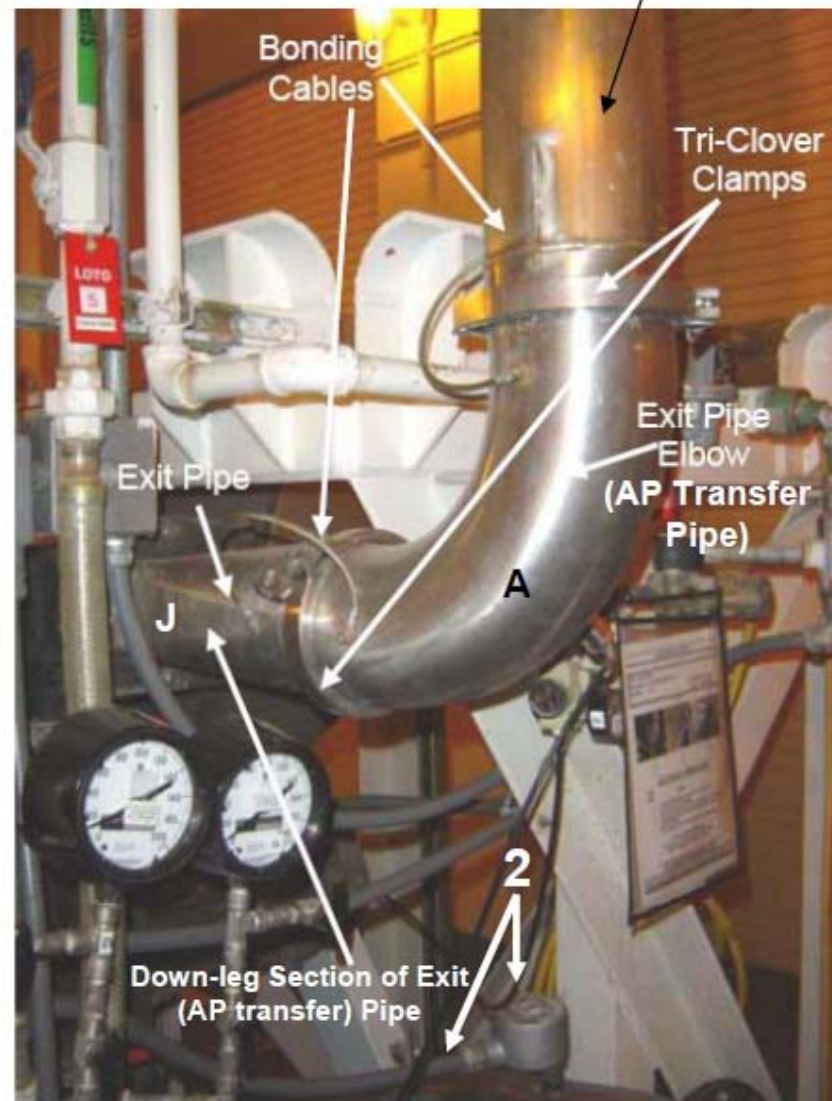
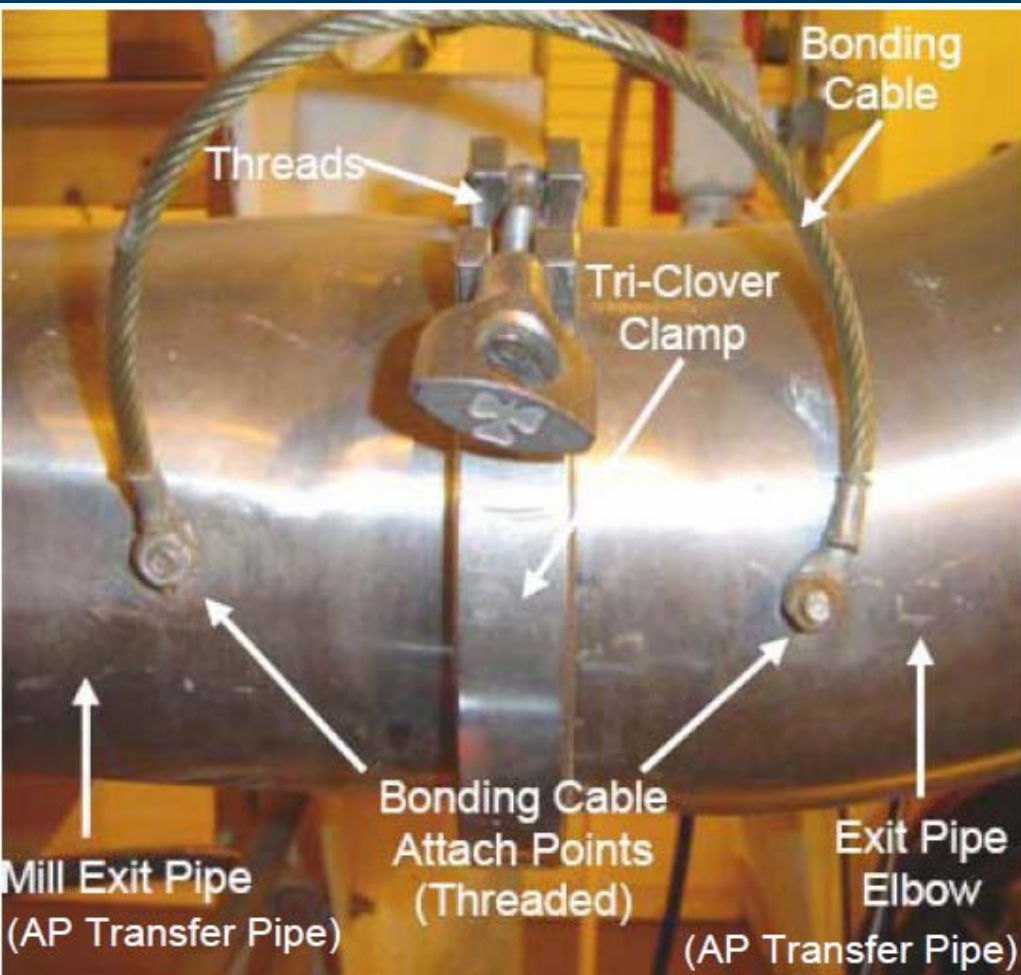


# Inside AP Grinding mill



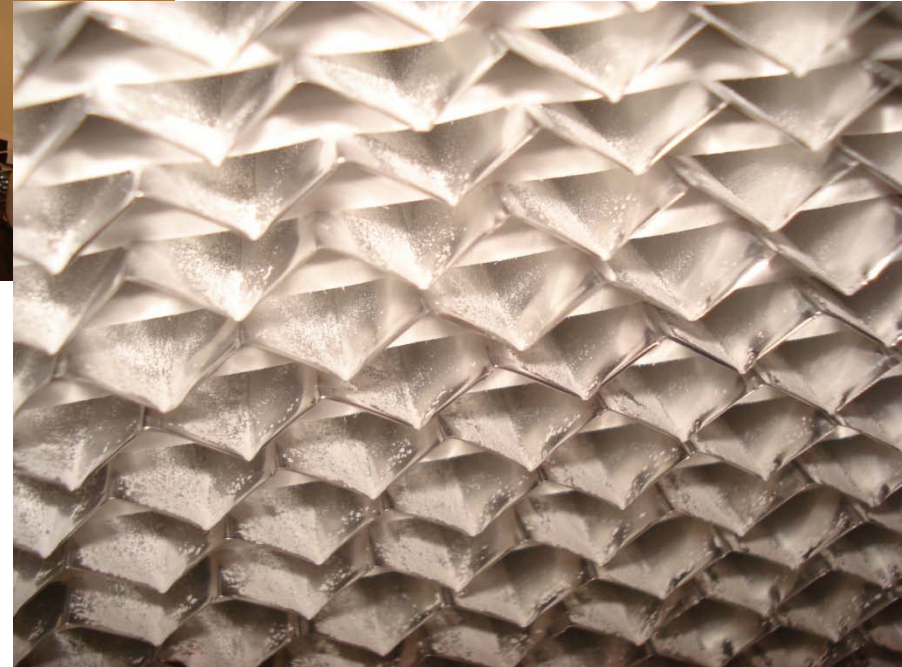


# AP Grinding Equipment



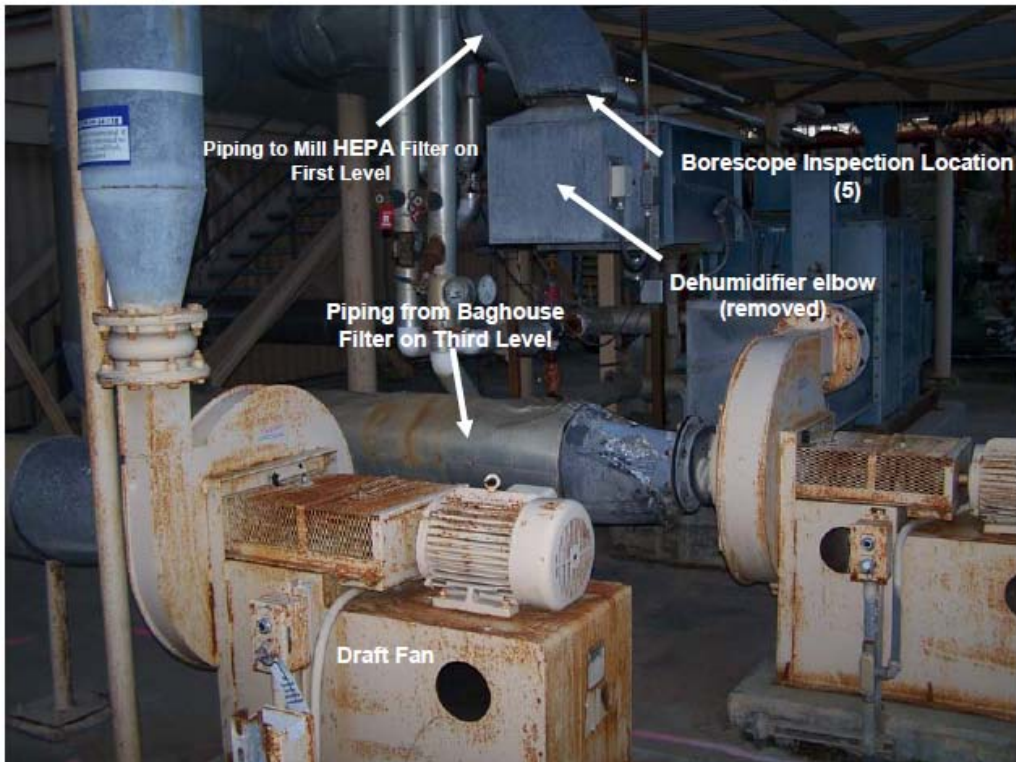


# AP Filtration System



# AP Filtration System

Piping, Draft Fan, and Dehumidifier on Ground Level  
(draft fans and dehumidifier elbow will have been removed)



HEPA Filter Unit on First Level (filter unit and piping will be removed)



Baghouse Filter Unit Piping on Third Level  
(filter unit and piping will be removed)

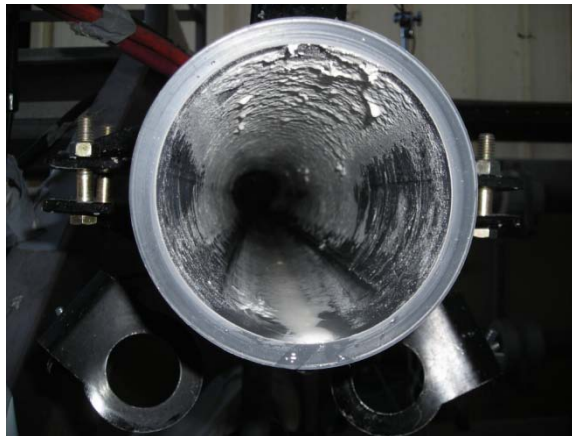




# Waste Propellant Treatment Unit



# Waste Propellant Treatment Unit

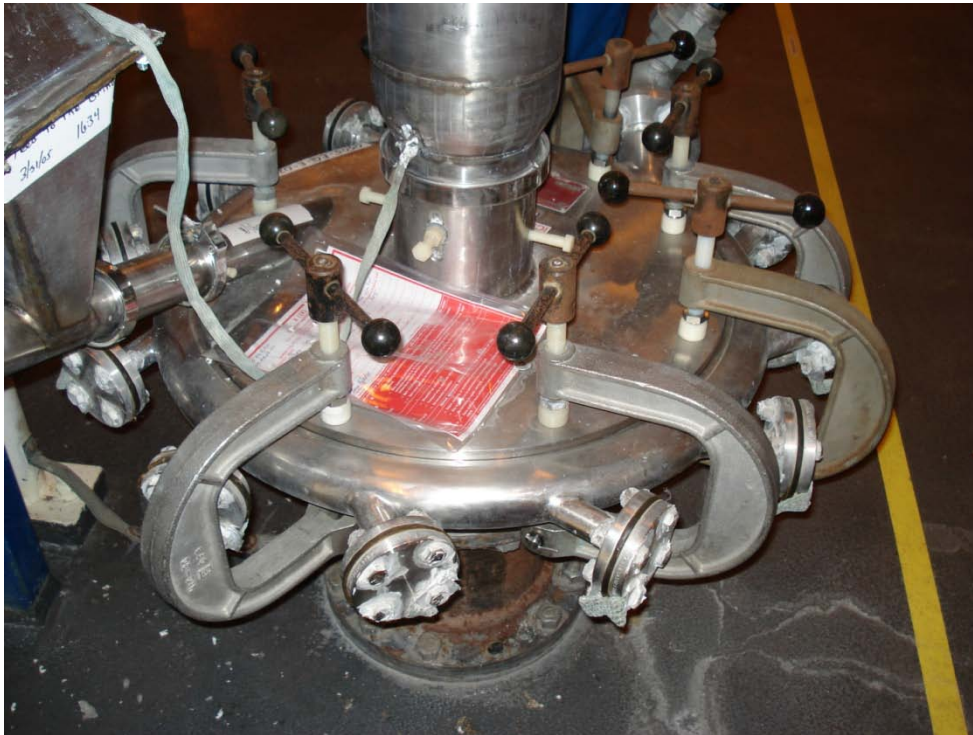


# HMX Grinding and Drying

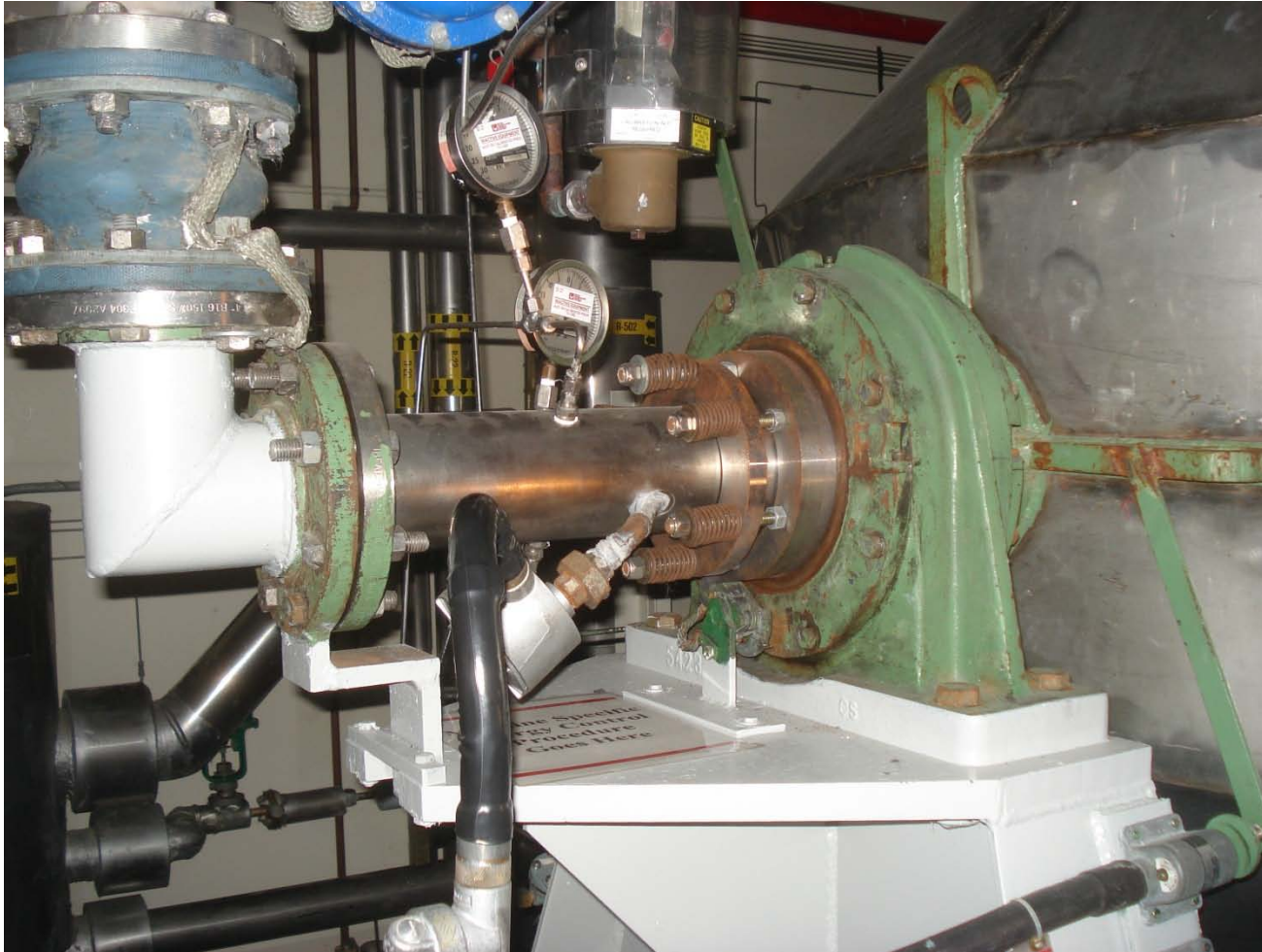




# HMX Grinding and Drying

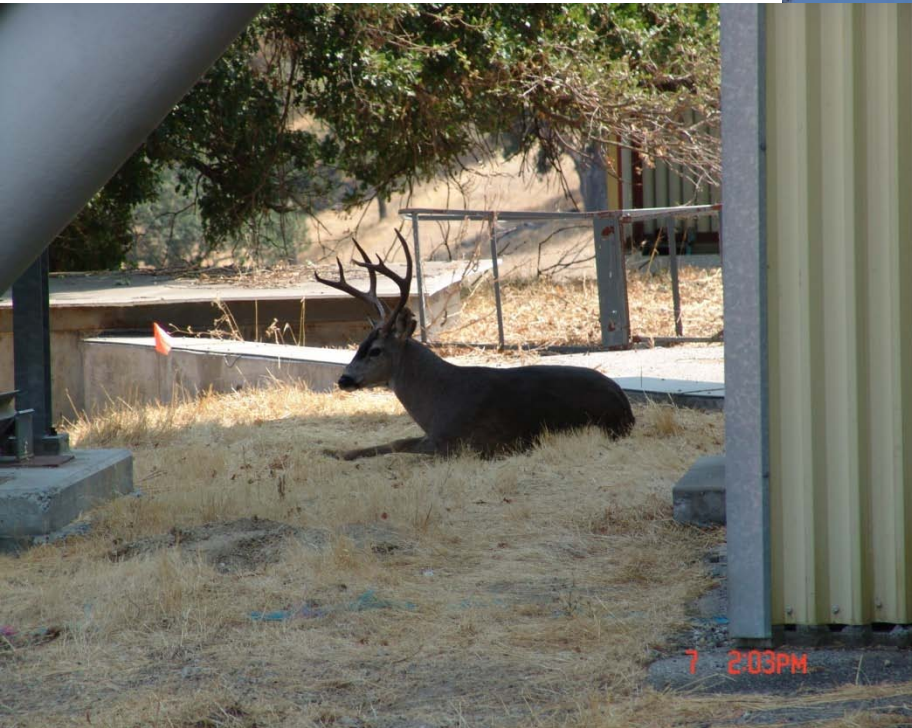


# HMX Grinding and Drying





# HMX Grinding and Drying





# HMX Grinding and Drying



# Liquid Propellant Test Area



Figure 1. RT-6 Air Lines and Thrust Take-out Assembly



Figure 2. RT-6 Vitiator and Air Lines

# Liquid Propellant Test Area

Equipment and Location	Specific Hazards	Tag*	Operation(s)
8. Oxygen supply for igniter	OXYGEN: Flammable, High Pressures	HAZARDOUS: 11-008	A. Open red taped 3/8-inch oxygen line at 3 places: to regulator and both sides of pneumatic oxygen valve B. Open blue taped nitrogen line to dome of regulator. C. Open blue taped nitrogen line to supply. D. Open blue taped nitrogen line to pneumatic oxygen valve.
9. Fuel supply for igniter	FUEL: Flammable, High Pressures	HAZARDOUS: 11-009	A. Open blue taped nitrogen line from 2-way solenoid valve to the pneumatic fuel valve. B. Open red taped 3/8-inch lines on two sides of pneumatic fuel valve.

\* Tag type consists of four separate fluid categories (Inert, Unknown, Hydraulic, & Hazardous Fluids).

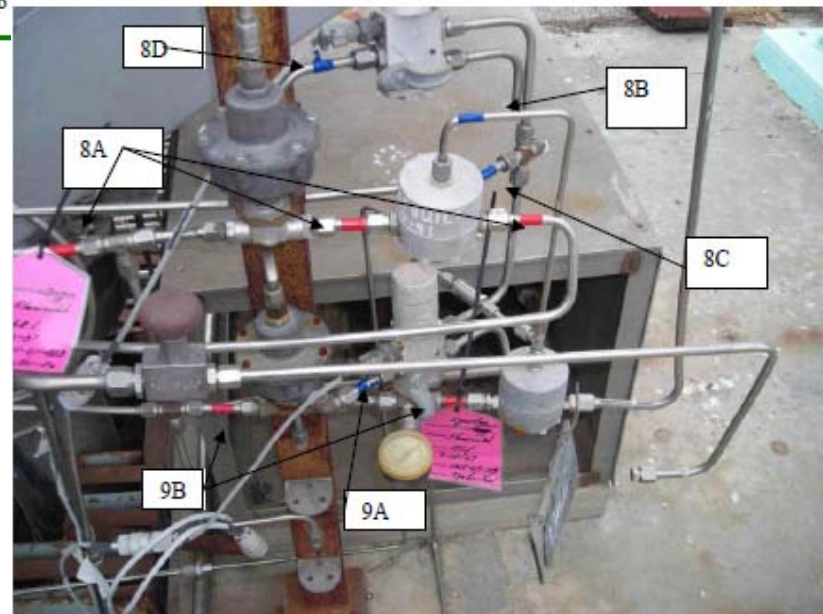


Figure 12. 11-008 Igniter-Oxygen System and 11-009 Igniter-Fuel System



# NG Sparging & Transfer



# NG Sparging & Transfer





# NG Sparging & Transfer



# Cast/Cure Ovens





# Cast/Cure Ovens





# Cast/Cure Ovens



View of Vaneaxiel Fan and Duct connection to Heat Exchanger and Filter Bank on the Exterior of the MIGO

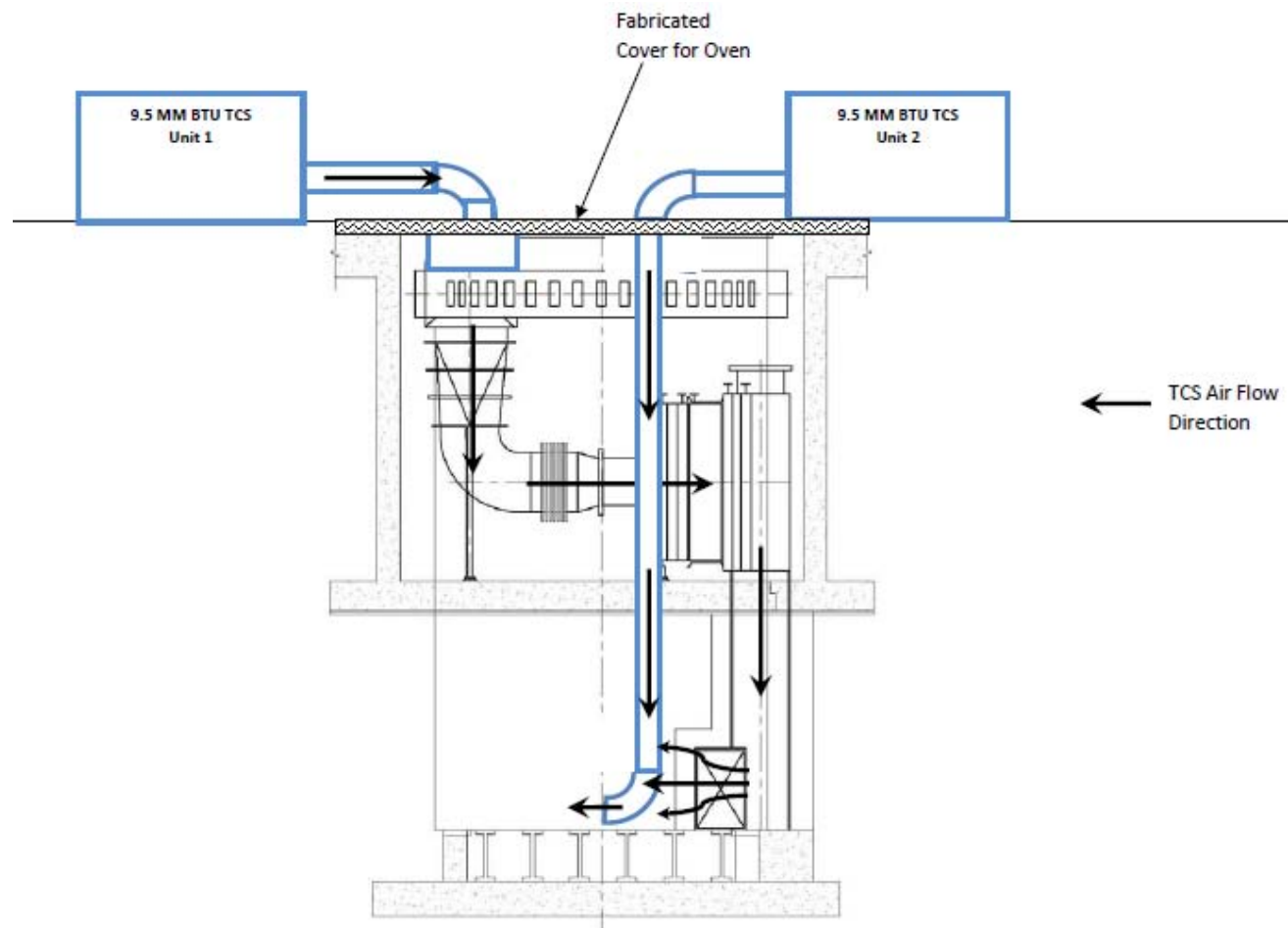


View above of Vaneaxiel Fan and Duct connection on the Exterior of the MIGO

# Cast/Cure Ovens



# Cast/Cure Ovens – Thermal Decon: PIKA



# Equipment with Inaccessible Parts





# Propellant Cocktail in Mixer Vacuum Port



# Propellant Contaminated Equipment





# Propellant Contaminated Equipment Thermal Decontamination - PIKA



# Contaminated Ducting





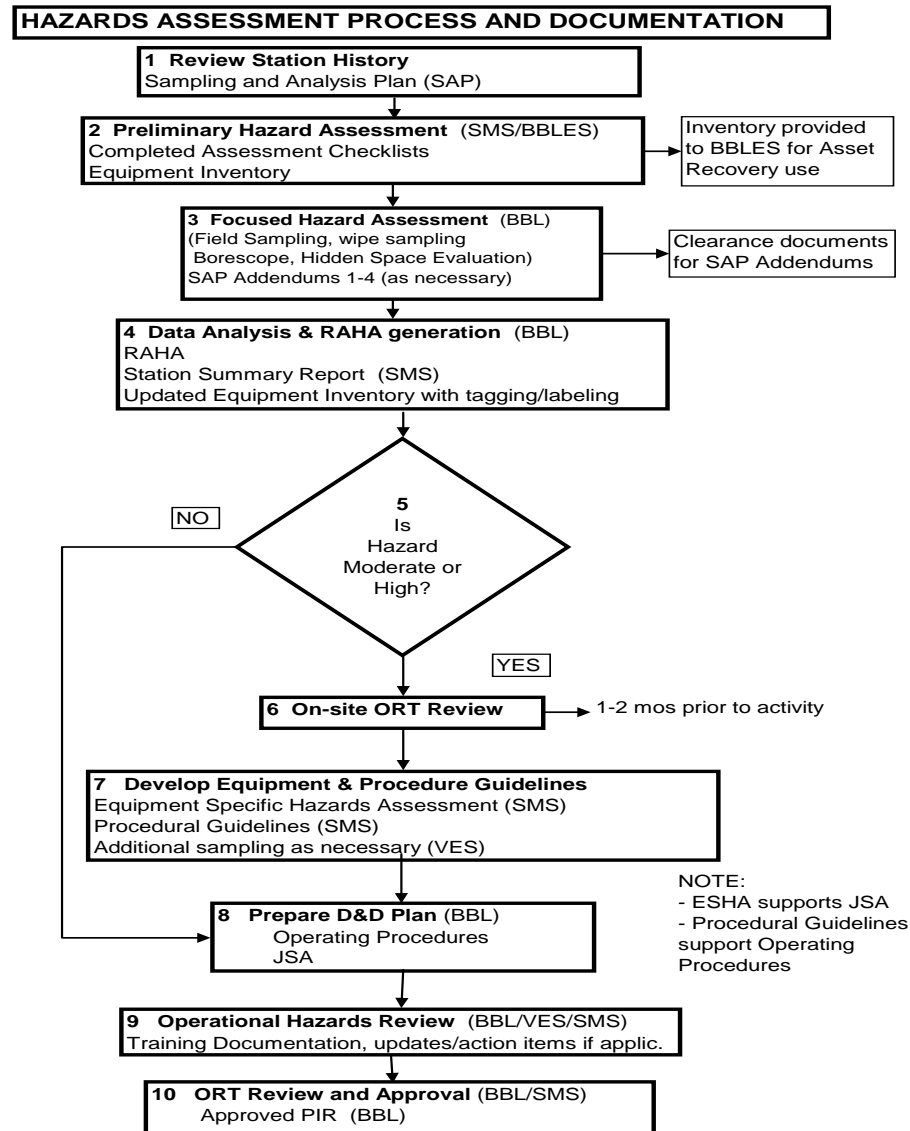
# Misc. Equipment Evaluation and Tagging



# Risk Management Principles Fundamental to Safe Decommissioning Operations

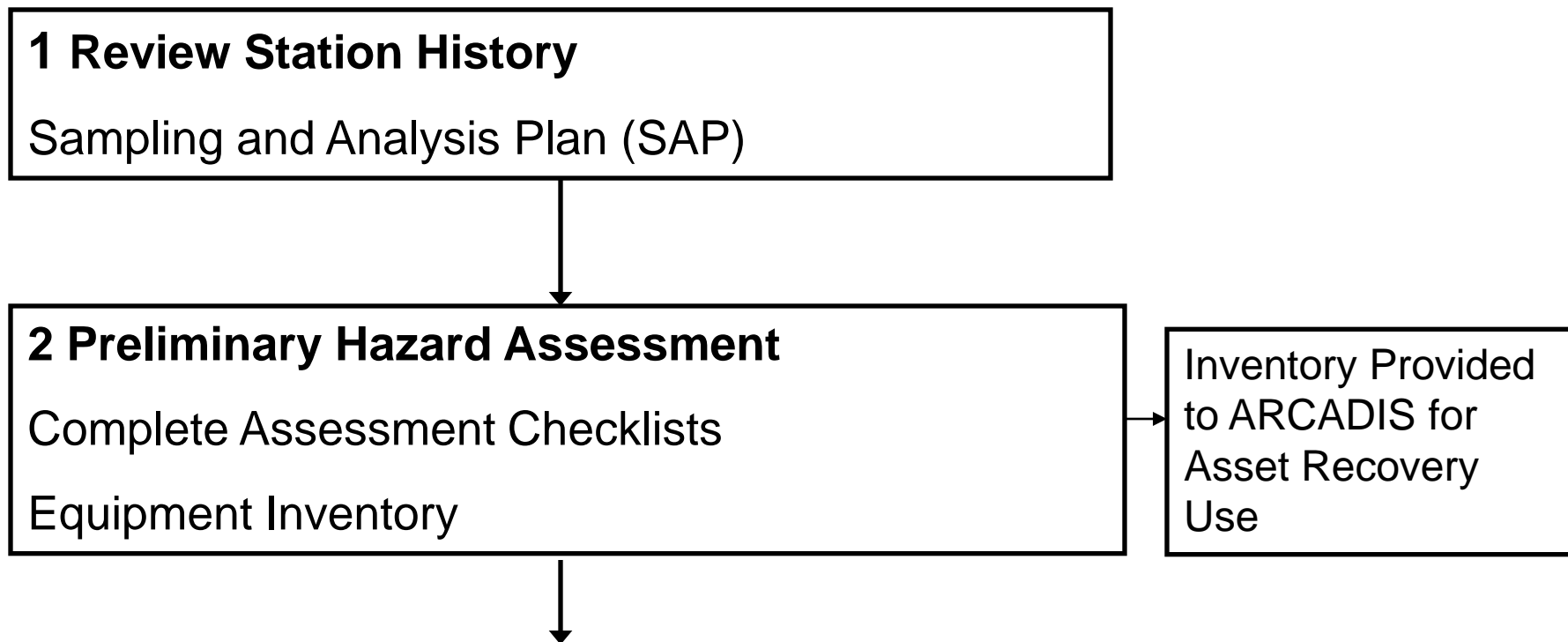
- Unique Decommissioning Issues:
  - Varied Station/Building uses
  - Equipment/Facilities with varying levels of contamination
  - Equipment/Facility Access
  - Sampling & Analysis
  - Disassembly/Decontamination
  - Final disposition of equipment/facility components
    - Asset Recovery
    - Landfill
  - Regulatory Compliance (PSM, Environmental, Safety, etc.)
- Systematic Risk Assessment and Management Essential
  - Tailored to address Decommissioning issues
  - Focused properly on potential hazards

# Risk Assessment Approach Flow Chart





# Hazards Assessment Process and Documentation



# Hazards Assessment Process and Documentation

## 3 Focused Hazards Assessment

(Field Sampling, Wipe Sampling, Borescope  
Hidden Spaces Evaluation)

SAP Addendums 1-4 (as necessary)

Clearance documents  
for SAP

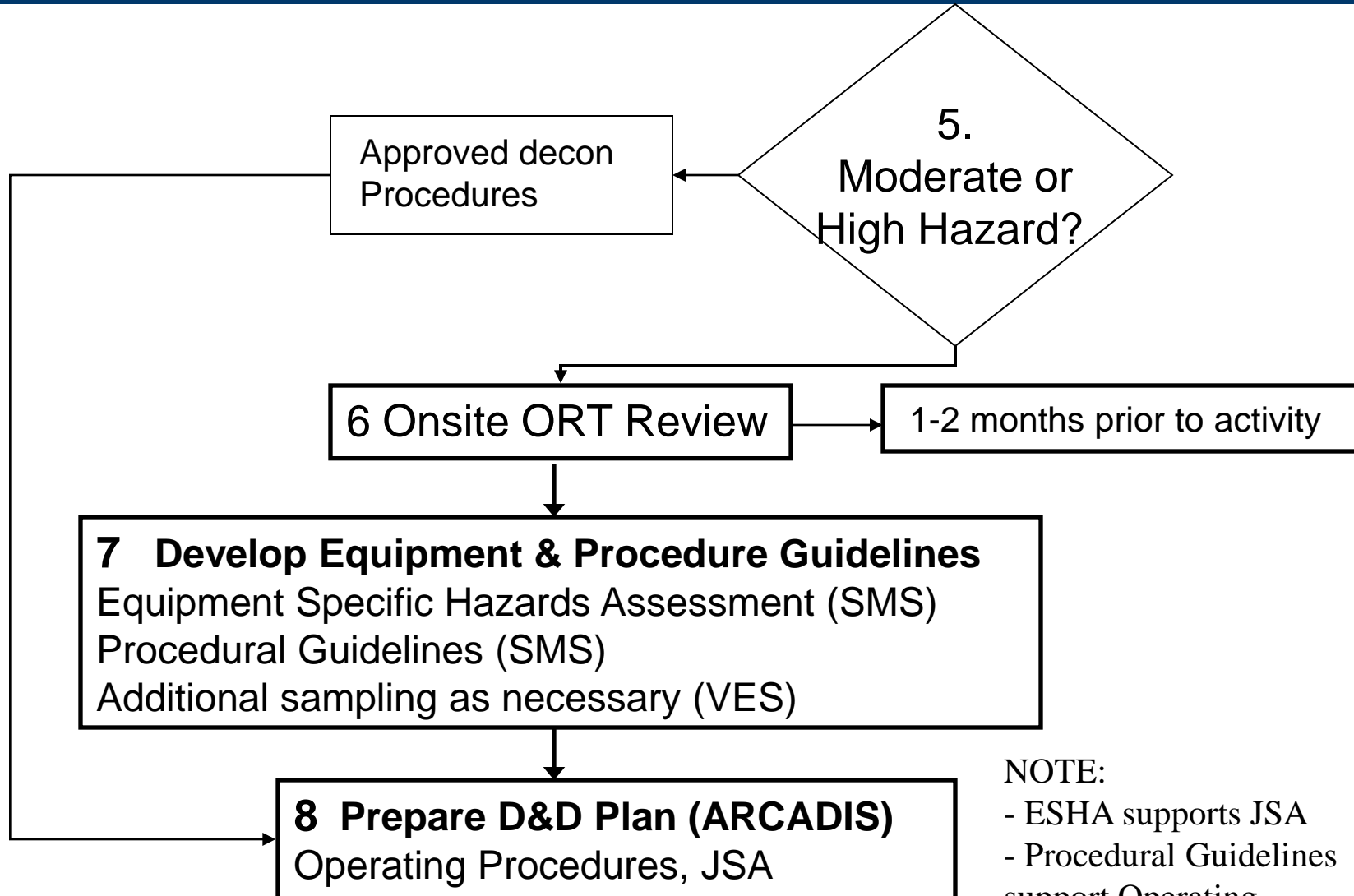
## 4 Data Analysis & RAHA Generation

Risk And Hazards Assessment (RAHA)

Station Summary Report (SSR)

Updated Equipment Inventory with tagging/labeling

# Hazards Assessment Process and Documentation



**NOTE:**

- ESHA supports JSA
- Procedural Guidelines support Operating Procedures



# Hazards Assessment Process and Documentation

## **9 Operational Hazards Review (ARCADIS/VES/SMS)**

Training Documentation, updates, action items if applicable



## **10 ORT Review and Approval (ARCADIS/SMS)**

Approved PIR (BBL)

# Summary

- Decommissioning of a Explosives Manufacturing Site Pose Unique Risks
- Technology can be properly applied to safely decommission facilities
- Decommissioning provides is a unique opportunity to effectively combine:
  - Technology
  - Risk Management Principles
  - Technical Skill/Disciplines
  - Program Management

# Summary

- Pratt & Whitney Rocketdyne (PWR) established proper Performance Expectations and Requirements
- PWR and the ARCADIS Team Collaborated at all levels to Achieve the Desired Expectations and Requirements
- Systematic Risk Management Works
  - All High Hazard Building are Removed
  - Over 900,000 man hours on site without a lost-time injury

